A SUPPLEMENT to the fifth annual report of the United States' Geological Survey has just been published. It consists of an enumeration, with descriptions by M. Lesquereux, of tertiary fossil plants collected by Dr. F. V. Hayden in 1870, from which some important climatic and other conclusions are drawn.

IT is stated that a plan has been submitted to the Spanish Government for a tunnel under the Straits of Gibraltar, which might be connected with the shortest route to India. The length to be traversed would be 13,800 metres, while that of the contemplated Dover and Calais tunnel is stated as 32,000.

THE late thunderstorms have done considerable damage to the Postal Telegraphs of the United Kingdom. Demagnetisation of needles, and in a large number of instances the fusing and complete destructions of the instrument coils, show that the want of an efficient lightning protector is still much felt.

CORK trees are being extensively introduced into Southern California.

FORMS OF SOLAR PROTUBERANCES [*]

PROFESSOR TACCHINI gave a full account of some of the work recently done by the Italian Society of Spectroscopists, which will be read with interest. At the beginning of his discourse he dealt specially with the observations on the solar protuberances, made with the view of throwing light on the question, whether the strata below the sun's chromosphere are solid, liquid, or gaseous. If we suppose that the protuberances have the form of jets, that is to say, narrow at the base and spreading out like a fan, as in the jets of gas which issue from terrestrial volcanoes, and if, moreover, instead of being composed of one element or a small number of elements, they are composed, from base to summit, of numerous materials, then it will appear probable that they are produced by eruptions taking place through a strongly resisting medium; and consequently that there must be already formed, on the surface of the sun, a crust solid enough to resist, for the most part, the powerful tension of the internal incandescent gases, which, breaking through this crust at certain points, give rise to violent eruptions, constituting the phenomenon of the solar protuberances. On the other hand, if all or most of the protuberances have a wide base and taper upwards like a pyramid, if their composition is simple, perhaps of the same materials as the chromosphere—a complex composition occurring only in a few of them, and at the base or at a small height above it—then the protuberances, properly so called, must be regarded, not as true eruptions, but as alterations of the chromosphere in those parts, where, through special circumstances, the composition of the subjacent strata becomes modified, either by an outflow of the internal constituents of the solar sphere—in which case the phenomenon is brought about by internal causes—or by disturbances arising in particular zones in consequence of movements developed in the sun's atmosphere, in which case the protuberances are produced by external causes; in other cases both these causes may concur in the production of the phenomena in question.

These considerations are sufficient to show the great importance of establishing the general character of the solar protuberances, and for this purpose, and to avoid certain sources of error, Prof. Tacchini invited P. Secchi, at Rome, and Prof. Lorenzoni, at Padua, to join with him in making contemporaneous observations of the solar protuberances. The proposal was favourably received, and it was agreed that from the 1st to the 13th of July, 1871, observations of the entire limb of the sun should be made from 7 to 10 o'clock.

The spectroscope employed by Tacchini at Palermo is formed of three direct vision prisms, constructed by Tauber, of Leipzig; that of P. Secchi is an instrument with angular vision, somewhat inferior in power to the Palermo instrument; and that of Prof. Lorenzoni is a direct-vision spectroscope which was used in Sicily in the observation of the total eclipse of 1870.

A comparison of the observations made at Rome and at Palermo led to the following results:—

1. All the masses are found indiscriminately in the drawings made at Rome and at Palermo; the most remarkable peculiarities of the chromosphere are likewise reproduced in both.
2. The principal characters of the forms of the protuberances are identical in the two sets of drawings; the direction and position of the plumes, the luminous masses, and frequently the regions of the chromosphere where the flames have a peculiar appearance, are perfectly identical.
3. The heights of the protuberances are for the most part the same, notwithstanding the diversity of the methods employed for measuring them.
4. The differences in the two sets of delineations are of two kinds: the first arising from the mode of drawing, the second from the greater distinctness of vision at Palermo. Other differences are real, being due to the rapid changes taking place in the protuberances.

At Padua the observations were limited to the delineation of individual protuberances; these were found to be the same in form and altitude as those seen at Rome and Palermo, thus affording proof that at the three stations, with different means of observation, the objects seen were identical, and removing any doubt that might previously have existed as to the power of the spectroscope to afford accurate results respecting the chromosphere and the forms of the protuberances.

Tacchini next proceeded to consider the general form of the protuberances. By observations with the spectroscope, continued from March 1871 to February 1872, he found that out of 2,903 protuberances, only 234, or abour 8 per cent., have the form of a tree or of a fan, that is to say, are narrow at the base and spread out towards the upper part, as if they were produced by volcanic eruptions, whereas the remaining 92 per cent. have a broad base and taper upwards like a pyramid, seem, therefore, to be due rather to a simple throwing up of the substance of the chromosphere. He, therefore, regards the general form of the protuberances as inconsistent with the existence of a solid crust on the surface of the sun. This is entirely in accordance with the English work.

When the chromosphere is observed with large instruments—and under peculiarly favourable conditions—it does not present the appearance of a continuous level stratum, as should be the case if it were solid, pasty, or liquid, but often appears to be formed of a continuous series of very distinct flames.[*] It looks indeed like a general conflagration, more or less developed, which is incessantly renewed with greater or less force, and with especial violence in particular parts, where it gives rise to the protuberances. In small instruments, on the contrary, the chromosphere appears smooth, excepting certain parts where the flames rise to an unusual height. In like manner the details of the protuberances, and especially their outlines, as observed with small instruments, are not comparable with those made with large telescopes, which must necessarily afford a higher degree of definition.

Tacchini next described certain observations which tend to show that the so-called jets, projected upwards from the chromosphere, have their counterpart in a descent of matter from above, in a kind of solar rain, when a mass or cloud of luminous hydrogen suspended in the sun's atmosphere throws off filaments on both sides, which gradually descend and unite at the sun's edge, thereby forming a protuberance which exhibits the arborescent or fan-like form usually attributed to an eruptive jet. This is a new point of great interest.

The theory which attributes the solar protuberances to violent eruptions forcing their way through a solid crust, or a liquid of great resisting power, may, Tacchini remarks, appear to derive some support from the chemical composition of the protuberances. If the masses which project above the chromosphere were found to contain many materials different from those which compose the chromosphere itself, there would be good reason for regarding them as projected from the interior of the sun. And, in fact, some of the protuberances have a somewhat complex chemical composition, the bright lines observed in their spectra often corresponding to magnesium, iron, sodium, titanium, calcium, barium, nickel, chromium, copper, together with eight other lines which may belong to as many different substances; in all therefore eighteen elements, besides hydrogen and the element provisionally named Helium, which is never absent, and represents the constant material of the entire chromosphere. On August 27 last in a single protuberance nine different substances, represented by a brilliant spectrum of twenty-four bright lines, nine of which belonged to iron were seen.

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[*] "On the Forms of the Solar Protuberances and the Regions of Magnesium and Iron on the Surface of the Sun." By P. Tacchini (Public Conference held on Feb. 18, 1872, in the Royal University of Palermo).

[*] See Lockyer, Proc. R.S. vol. xvii. 1870, p. 354.

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But is this rich composition common to all the protuberances, or limited to a certain number? and do these materials extend throughout the protuberance, or are they confined to a limited portion of it?

Tacchini's observations show that the varied composition in question is limited to a very small height; in other words, to the mere base of the protuberance, whereas the higher portions are composed exclusively of hydrogen and the element D_3. Now, if the protuberances were the result of violent eruptions, the substances ejected with such force could not fail to attain a considerable height above the base of the protuberance, which is contrary to observation. Moreover, it is not all the protuberances that give a mixed spectrum; that is to say, they are not all formed of numerous materials, as they should be, at least in the majority of cases if they were produced by violent eruptions. According to Tacchini's observations, only 10 out of 100 protuberances give a mixed spectrum, the remaining 90 giving spectra which exhibit only the hydrogen lines and the line D_3. He also finds that in all the spectra which he has observed, either of protuberances near the sun's edge, or of clouds and filaments of greater height, the hydrogen-lines never occurred alone, but always accompanied by the line D_3. In one case only were the hydrogen lines and D_3 accompanied by other bright lines in the distinctly higher portions of the protuberances. This was observed on December 19, 1871, on a magnificent protuberance resembling a great conflagration, the central part of which exhibited two red lines.

If the protuberances were formed of materials violently ejected from the interior of the sun, it would follow that at every point of the sun's edge where a mixed spectrum occurs, that is to say, where there is evidence of the presence of numerous materials, there also the corresponding protuberance should exist; but observation shows the contrary.

From his first examination of the protuberances, indeed, Tacchini had been led to conclude that the bright protuberances alone afforded certain indication of a rich variety of materials;[*] but observing afterwards some parts of the sun's edge which, though free from protuberances, nevertheless had a peculiar structure, inasmuch as they were formed of a series of flames higher and brighter than usual, he was led to examine the spectrum of these portions more attentively; and he found indeed that there also, in addition to the lines of hydrogen and D_3, lines appeared corresponding to many other substances. A very careful examination of the sun's edge was accordingly made in August and September 1871, the result of which was to show that in very extensive tracts of the edge, amounting to $\frac{1}{6}$ of the whole, the entire chromosphere was invaded by the vapours of various metals, although these same parts of the edge were not covered by protuberances, an observation before made by Lockyer.[†]

These tracts continued to show themselves more or less extensively for many days afterwards in the same part of the sun's limb, representing in their aggregate vast regions of the surface where the hydrogen of the chromosphere was mixed with many other substances which commonly exist at the base of the chromosphere. Thus on the 28th of August and 17th of September, 1871, throughout an area of 60°, from the position 30° to 90°, the edge gave a mixed spectrum, although the constituent substances were not found to be present in the same number at all points of this arc; the greater number indeed were found at the middle of the arc, while at the ends they were reduced to magnesium, hydrogen and D_3 of the chromosphere, so far as this last-mentioned line may be regarded as belonging to a peculiar substance. This order in the number of substances on the portions of the edge which give a mixed spectrum, has been observed so frequently, that the regions of the sun corresponding to the aggregate of these successive tracts may be regarded as isolated portions of the solar surface, in the centre of which there is found a large number of different substances, this number diminishing towards the edge of each of these regions, where it reaches its minimum; and if we leave out of consideration the materials of the chromosphere which are common to the whole surface of the sun, we may say that at the borders of these regions there remains nothing but magnesium. In these tracts or regions, indeed, though the composition might be different in different parts, magnesium was never absent; for this reason Tacchini designates these portions of the surface as *magnesium regions*.

Instead then of special points marked by eruptions, we find on the sun's surface large regions exhibiting throughout a complex spectrum, but not covered by protuberances; and this affords the strongest argument for not regarding the protuberances as a phenomenon of true eruption. We cannot therefore admit the existence of a solid or highly resisting liquid stratum, but rather a purely gaseous envelope, such as may permit of the ready mixing of the internal materials with those of the chromosphere on a vast scale, thereby giving rise to the regions above designated as regions of magnesium.

This view, however, does not absolutely exclude the occurrence of eruptive phenomena; for if these materials show themselves in the chromosphere at certain determinate points, they must have issued or been ejected from the centre towards the circumference. Tacchini, however, thinks that he has proved that these eruptions are not violent, and do not take place through a strongly resisting medium.

Contemporaneously with the determination of the angles of position of the protuberances, and of the portions of the chromosphere which exhibited a mixed spectrum, similar determinations were made of the positions of the faculæ and regions of faculæ visible or near the edge. A comparison of the two series of determinations thus made showed the coincidence of the magnesium regions with the regions of the faculæ. The positions of the protuberances on the other hand did not coincide with either.

The limits of the regions of magnesium and of the faculæ, on either side of the sun's equator, were found to be as follows:—

Regions of Magnesium, August 1871	+ 60° − 27
September	+ 60° − 32
Regions of the Faculæ, August	+ 43° − 32
September	+ 64° − 32

Considering now the magnesium regions above described, and the intensity of the phenomena there exhibited, it is clear that at any given epoch, the luminous intensity of the solar disc may vary considerably, and exhibit great differences as compared with that of the general envelope. At such times the solar atmosphere will not be uniformly illuminated, but will include a number of cones, varying in extent and brightness according to the different magnesium regions existing on the sun; and Tacchini suggests that in the case of total eclipses of the sun, during which the solar atmosphere becomes visible to us in the form of an aureola, this aureola which is differently illuminated in different parts, and therefore presents the appearance of plumes perpendicular or oblique to the edge of the moon, may arise from the cones embracing a large extent of surface corresponding to that of the magnesium regions.

Whilst Tacchini was studying the magnesium regions, Lorenzoni obtained evidence that the temperature of the sun's surface is least at the poles. The regions occupied by the metallic vapours corresponding to a certain line, which probably belong to the spectrum of iron, are called by Tacchini iron regions; they do not coincide with the regions of magnesium and of the faculæ, or with those of the protuberances, which are more limited.

Since the vapours of iron are diffused in the chromosphere on so vast a scale, and the magnesium regions also are so large as has been previously shown, Tacchini asks is it possible to admit the existence of a state of solidity or viscosity in those envelopes, or a temperature so low as some persons suppose? He regards such a view as totally inadmissible, and considers that all the observations above detailed point to the conclusion that the time is yet very distant when the sun will approach to those transformations which have reduced the earth to its actual state; and that the sun is still an entirely gaseous mass, relatively hotter at the centre, and cooler in the superficial strata, which we distinguish by the names of photosphere and chromosphere.

ASTRONOMY

On the Meteors of April 30-May 1[*]

Prof. Schiaparelli, in his list of meteoric showers whose radiant-points are derived from observations made in Italy within the last few years, describes one as occurring on April 30 and May 1, the apparent position of whose radiant is in the Northern

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[*] Tacchini's observations divide prominences as Lockyer has divided them.

[†] Proc. R.S. vol. xviii. p. 75 1879

[*] From *Silliman's Journal* for July, 1872.

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